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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OAST SPACE THEME WORKSHOP

VOLUME III

(NASA-TM-80008) OAST SPACE THEME WORKSHOP.
VOLUME 3: WORKING GROUP SUMMARY. 1:
NAVIGATION, GUIDANCE, CONTROL (E-1) A.
STATEMENT. B. TECHNOLOGY NEEDS (FORM I).
C. PRIORITY ASSESSMENT (FORM 2) (NASA)

N79-15120

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WORKING GROUP SUMMARY

I. NAVIGATION, GUIDANCE, CONTROL (E-1)

- A. STATEMENT
- B. TECHNOLOGY NEEDS (FORM I)
- C. PRIORITY ASSESSMENT (FORM II)

HELD AT THE
LANGLEY RESEARCH CENTER
APRIL 26-30, 1976



SPONSORED BY NASA-CODE RX

Foreword

The attached material represents the working papers from the OAST Space Theme Workshop held at the Langley Research Center, April 26-30, 1976, and contains a quick-look analysis of the proceedings. The material is unedited and intended for further use by the participants of the workshop and the planning elements of NASA concerned with space mission research and technology. It should be understood that the data do not represent official plans or positions but are part of the process of evolving such plans and positions.

Nearly 100 of the Agency's top technologists and scientists joined with another 35 theme specialists to produce this working document - a document that provides a technical foundation, including research and technology base candidates, for each of the six space themes.

The material in this report is considered essential to the development of Center initiatives in support of these themes. Copies of the report will be made available to the Center Management Board and the individuals at the Centers responsible for the FY'78 program planning cycle. The timing of this planning activity has caused us to distribute this document in this unedited form. Thus, it possibly contains errors, hopefully, more of a typographical rather than a technological nature. Nonetheless, the information contained is of a high professional level, reflecting the efforts of the workshop participants and will be invaluable to the planning and successful execution of the Agency's near- and far-term advanced technology program.

Stanley R. Sadin
OAST Space Theme Workshop
Chairman
NASA Headquarters
Study, Analysis, & Planning Office
Office of Aeronautics and
Space Technology

VOLUME III

I-A STATEMENT

NAVIGATION, GUIDANCE, AND CONTROL

The results of the Workshop indicate that the themes have many common navigation guidance and control needs. All the earth orbit themes have a strong requirement for attitude, figure and stabilization control of large space structures, a requirement not currently being supported. All but the space transportation theme have need for precision pointing of spacecraft and instruments. In addition all the themes have requirements for increasing autonomous operations for such activities as spacecraft and experiment operations, onboard mission modification, rendezvous and docking, spacecraft assembly and maintenance, navigation and guidance, and self-checkout, test and repair.

It is clear that major new efforts are required to conceptualize new approaches to large space antennas and arrays that are lightweight, ready deployable and capable of precise attitude and figure control. Conventional approaches offer little hope of meeting these requirements. Similarly, it is also apparent that the time has come to move from conceptual machine intelligence to applications. Increasing autonomy in the space program has great potential for reducing costs and ground support requirements and increasing mission return.

Some of the Functions That Can Benefit From Increasing
Automation or Autonomous Operations

- Orbit Changes
- Experiment Pointing
- Experiment Control
- Manipulation
- Data Evaluation and Reduction
- Telemetry Control
- Housekeeping Functions
- Locomotion Control
- Collision Avoidance
- Navigation and Guidance
- Attitude and Figure Control
- Payload Servicing, Repair or Retrieval
- Assembly of Large Structures
- Checkout/Status
- Mission Planning (Preflight and Real Time)
- Failure Detection and Reconfiguration
- Control of Consumables
- Rendezvous and Docking
- Entry and Landing

N, G & C NEW INITIATIVES

1. Advanced G&C components for S.T.S. including: CCD STAR TRACKERS, ELECTRO-MECHANICAL ACTUATORS & SENSORS FOR AUTO-RENDEZVOUS and Docking.
2. Science Platform Precision Pointing and Tracking System for non-inertial targets.
3. Experiment Isolation and Pointing System.
4. A dexterous manipulator for remote man-controlled assembly and servicing.
5. Control systems for Altitude and Figure Control of Large Deformable Structures.
6. Systems and Components for Autonomous Rendezvous and Docking.
7. Low Thrust Guidance and Navigation Program.
8. Space Teleoperator Experiment (STEV) Free Flying Modular Instrument Pointing Technology Laboratory.
9. Design Technology for Digital Control Systems.
10. Sensor development for inertial pointing.
11. Extended body Tracker Technology.
12. Correlation Landmark Tracker Technology.
13. Autonomous Guidance and Navigation Flight/Ground Demonstration.
14. Autonomous Mission Operations Sequencing & Control.
15. Dynamics and Control of Unmanned Planetary Entry and Landing Vehicles.

NAVIGATION, GUIDANCE AND CONTROL

KEY ISSUES

△ LARGE STRUCTURE CONTROL

- INTEGRATED STRUCTURE/CONTROL SOLUTIONS
- SENSOR/ACTUATOR/ANALYSIS CAPABILITIES

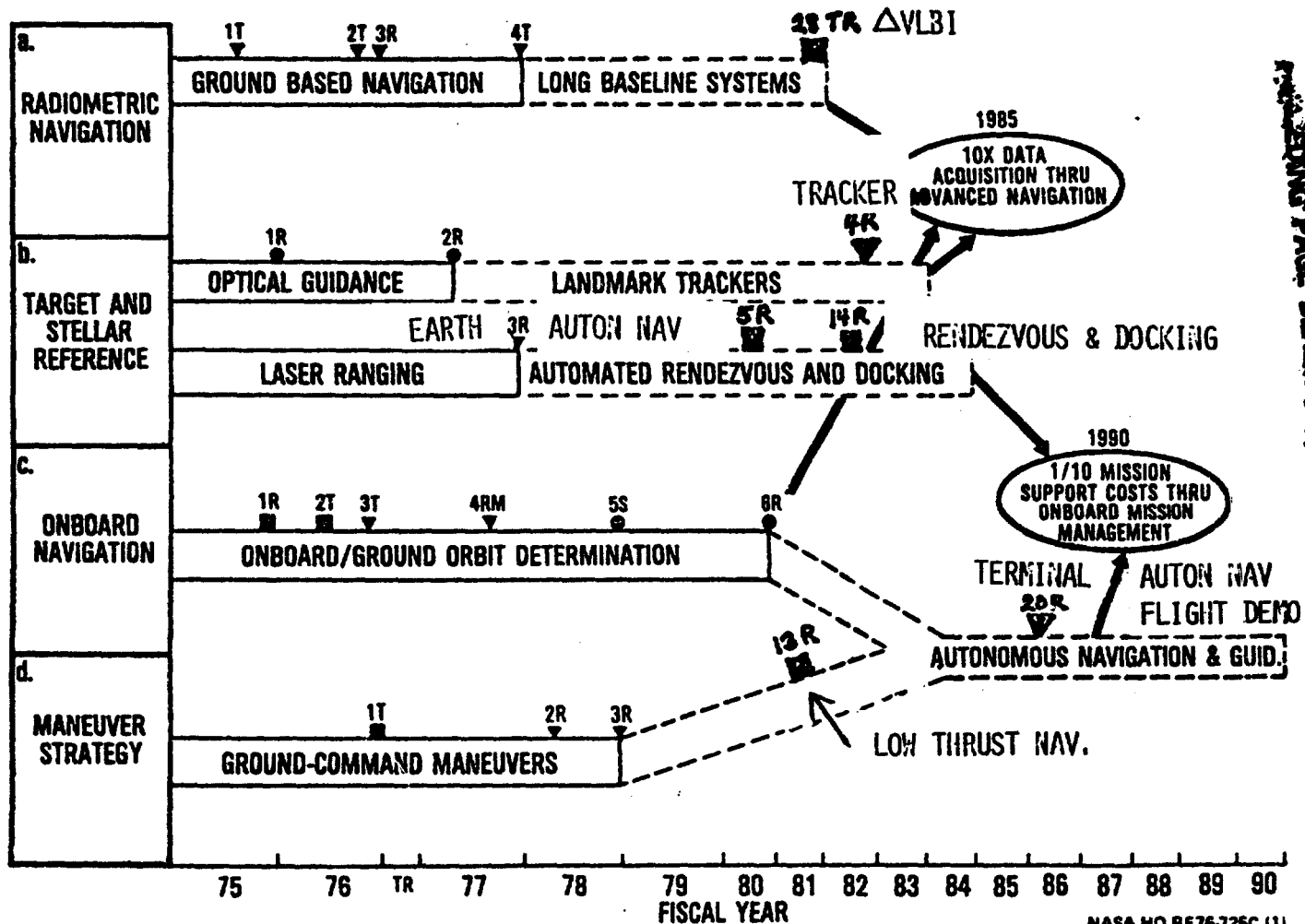
△ INSTRUMENT POINTING

- SENSORS/TRACKERS/MOUNTS
- ANALYSIS AND SIMULATION CAPABILITIES
- TRACKING SYSTEMS

△ AUTONOMOUS SYSTEMS

- NAVIGATION AND GUIDANCE
- ROBOTICS
- RENDEZVOUS AND DOCKING
- STATION KEEPING

1. NAVIGATION AND GUIDANCE



NASA HQ RE76-725C (1)
2-17 76

III-I-A-5

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RESOURCE SUMMARY

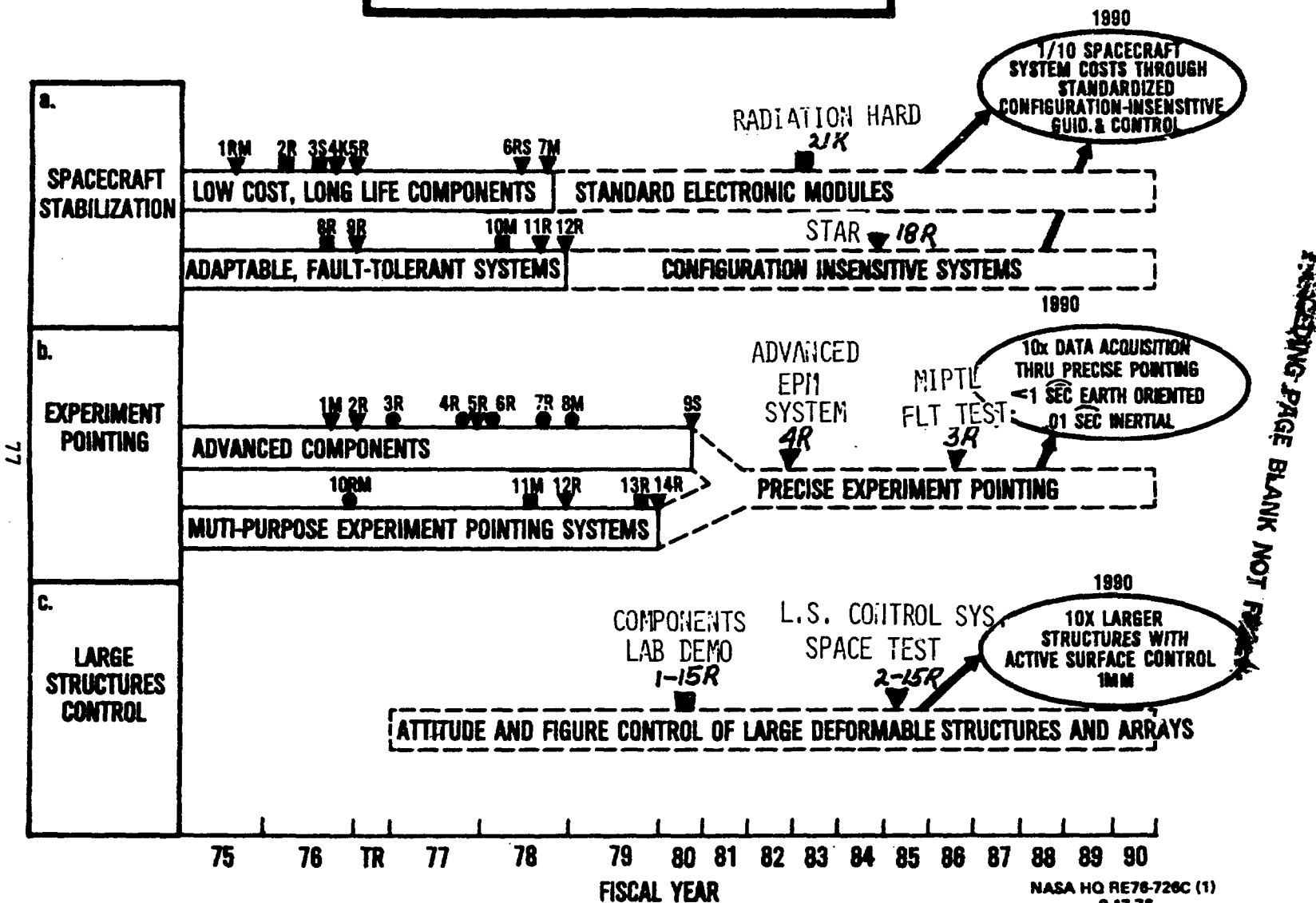
NAVIGATION, GUIDANCE, AND CONTROL

I. NAVIGATION AND GUIDANCE DISCIPLINE CATEGORY

FY		76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
RESOURCES																	
MANPOWER	INHOUSE			22	30	35	17.7	14	10								128.7
	CONTRACT																
FUNDING, \$M	INHOUSE			3.9	6.3	6.5	4.7	4.0	3.8								29.2
	CONTRACT																

NOTE: MANPOWER AND \$ ARE ADDITIVE, NOT REDUNDANT.

2. POINTING AND CONTROL



RESOURCE SUMMARY

NAVIGATION, GUIDANCE, AND CONTROL

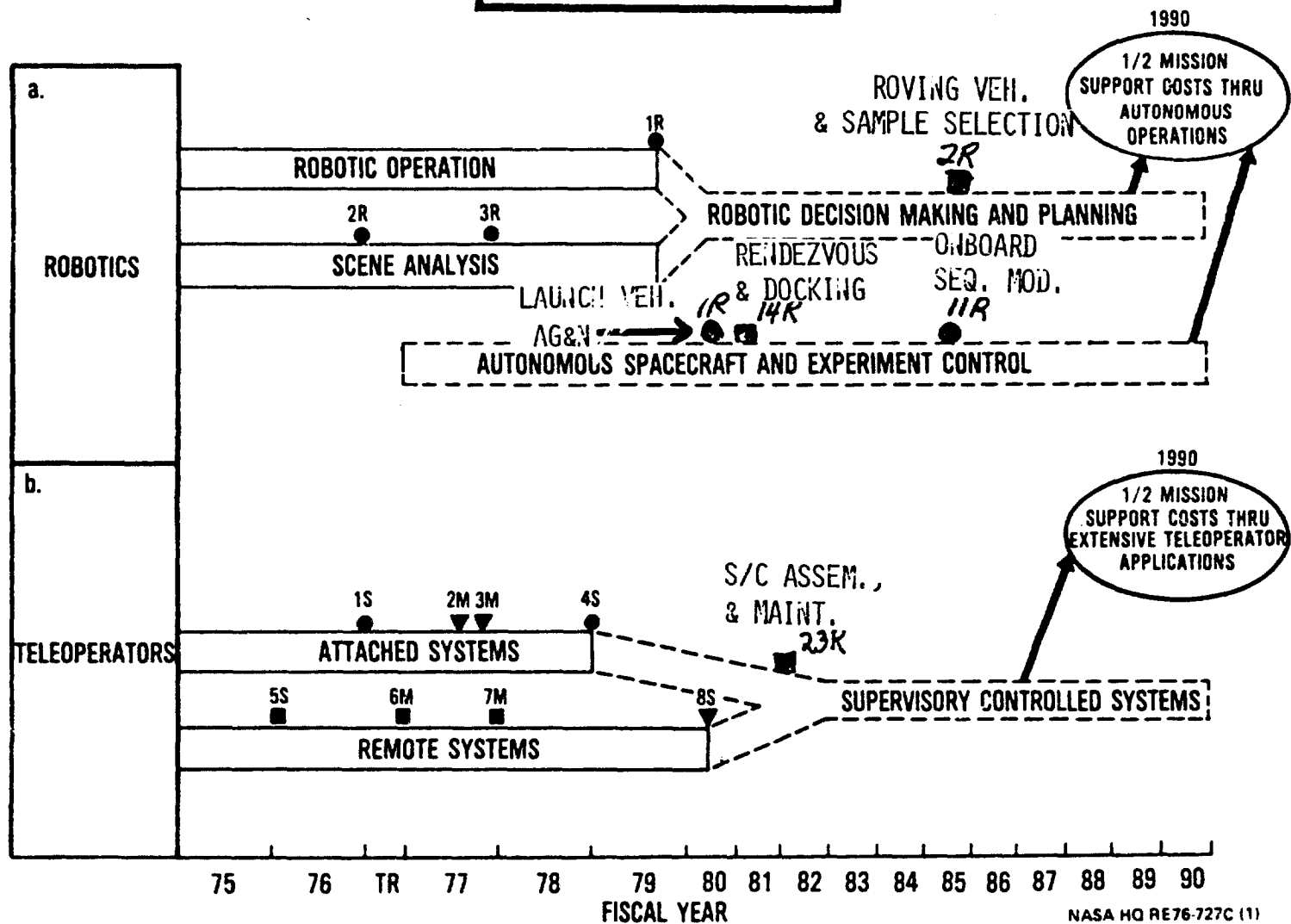
II. POINTING AND CONTROL DISCIPLINE CATEGORY

FY		76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
RESOURCES																	
MANPOWER	INHOUSE			60	80	84	73	61	60	55	35	30					538
	CONTRACT																
FUNDING \$M	INHOUSE			5.9	8.6	10.3	9.3	8.6	8.2	7.7	6.7	3.0					68.3
	CONTRACT																

NOTE: MANPOWER AND \$ ARE ADDITIVE, NOT REDUNDANT.

III-I-A-8

3. AUTOMATION



RESOURCE SUMMARY

NAVIGATION, GUIDANCE, AND CONTROL

III. AUTOMATION DISCIPLINE CATEGORY

FY		76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
RESOURCES																	
MANPOWER	INHOUSE			34	34	33	32	30	30	2.4	0						195.4
	CONTRACT																
FUNDING \$M	INHOUSE			4.1	4.0	4.0	3.9	4.1	4.1	2.4	2						28.9
	CONTRACT																

NOTE: MANPOWER AND \$ ARE ADDITIVE, NOT REDUNDANT.

RESOURCE SUMMARY

NAVIGATION, GUIDANCE, AND CONTROL

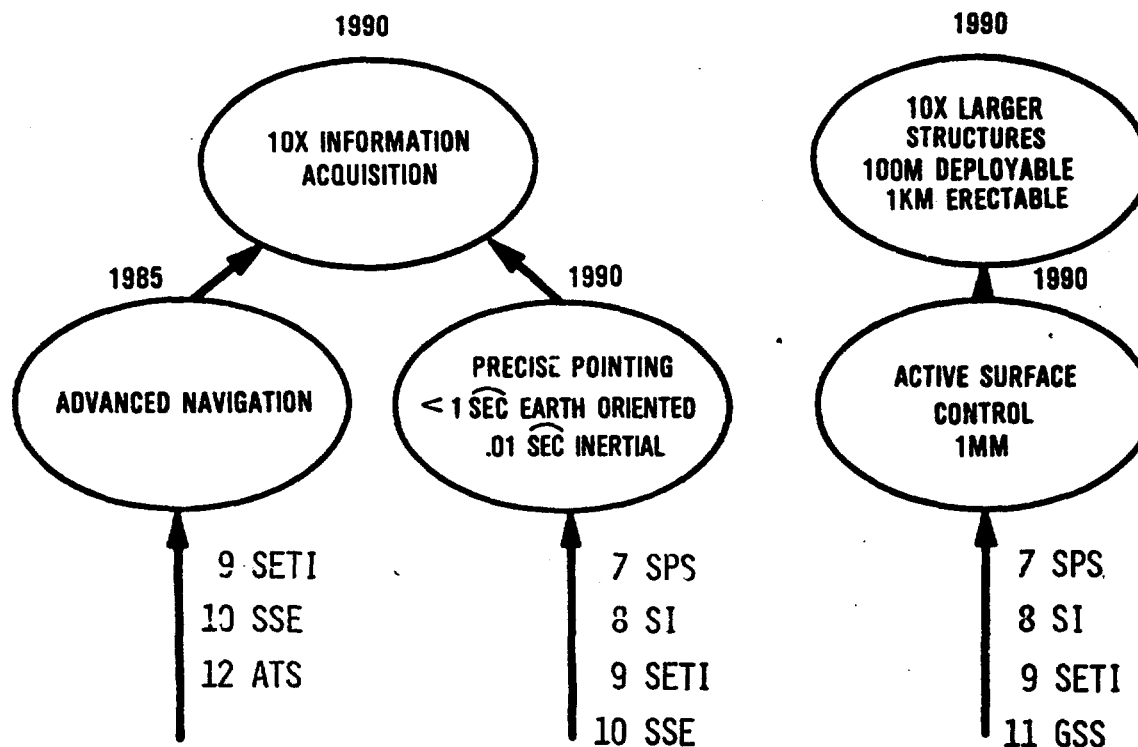
TOTALS

FY		76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
RESOURCES																	
MANPOWER	INHOUSE			116	144	152	123	105	100	57.4	35						832.1
	CONTRACT																
FUNDING, \$M	INHOUSE			4.1	18.9	20.8	17.9	16.7	16.1	8.7							113.3
	CONTRACT																

NOTE: MANPOWER AND \$ ARE ADDITIVE, NOT REDUNDANT.

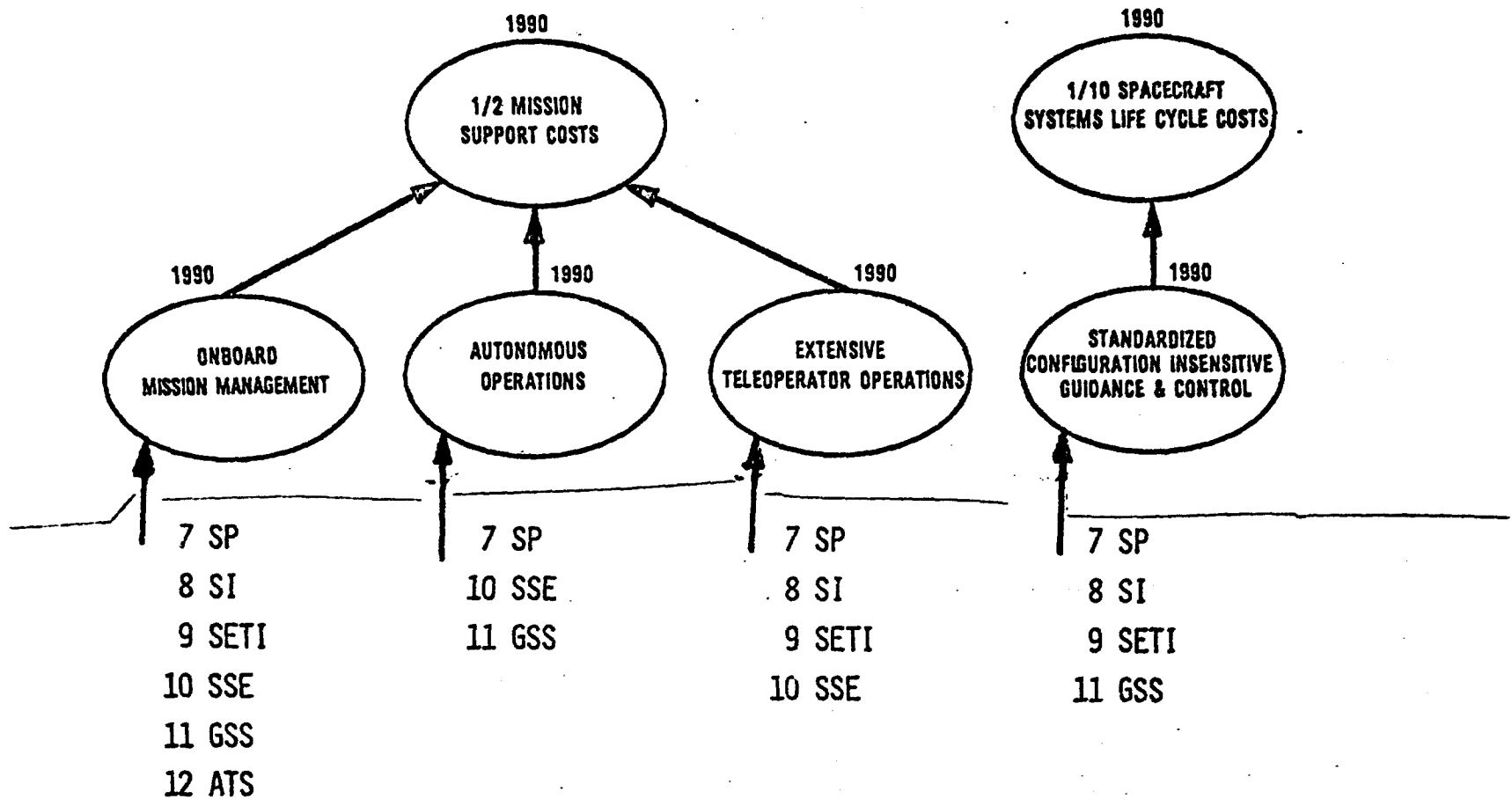
III-I-A-11

NAVIGATION, GUIDANCE AND CONTROL



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NAVIGATION, GUIDANCE AND CONTROL



5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY SIMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF _____

1. TITLE AUTONOMOUS GUIDANCE AND CONTROL
OF LAUNCH VEHICLES

NO. 12 / E1 / 1
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

TO MINIMIZE OR ELIMINATE THE NECESSITY FOR GROUND SUPPORT
(TRACKING, COMMUNICATION) FROM LIFT-OFF TO ORBIT INSERTION

3. NEED ANALYSIS

- a) LEVEL NOW 4, WILL BE LEVEL 7 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1985
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☐ MEDIUM ☒ LOW ☐
- e) TASKS NEEDED: STUDY ☐ ANALYSIS ☒ RESEARCH ☐
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY DATA PROCESSING HARDWARE, GUIDANCE AND
CONTROL SOFTWARE

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

● PRECISION NAVIGATION SYSTEMS WITH PRECISION GROUND
ALIGNMENT CAPABILITY

● RAPID ONBOARD ORBIT VERIFICATION TECHNIQUES

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF _____

TITLE AUTONOMOUS GUIDANCE AND CONTROL
OF LAUNCH VEHICLES

NO. 12 / E1 / 1
THEME / W.G. / TASK

DATE 4/28/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

THE DEVELOPMENT OF PRECISION NAVIGATION SYSTEM AND ALIGNMENT PROCEDURES AND EQUIPMENT TO PROVIDE ACCURATE INFORMATION FOR PATH CONTROL. THE DEVELOPMENT OF ONBOARD SYSTEMS/TECHNIQUES FOR RAPID ORBIT VERIFICATION.

7. ALTERNATIVE APPROACHES/OPTIONS CONTINUE TO USE GROUND TRACKING
FOR TRAJECTORY STATUS, RANGE SAFETY, AND ORBIT VERIFICATION

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

FY

[illegible][illegible]

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL OF STATE OF ART

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF _____

1. TITLE Roving Vehicles, Sample Selection/
Acquisition
NO. 1,8,10/E-1/2
THEME / W.G. / TASK
DATE 4 / 26 / 76

2. OBJECTIVE

To develop roving vehicles for support of sample analysis and/or sample
return missions and for general survey. Also rovers for maintenance and
service of lunar or other bases.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 3, WILL BE LEVEL ☒ 7 UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1990
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
e) TASKS NEEDED: STUDY ☐ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☒ Computer simulation (Check one or more)
f) R&T BASE CANDIDATE Yes 506-19-32 960K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Development of advanced self adaptive software

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Eye/hand coordination, obstacle avoidance/navigation, hazard avoidance,
development of dexterous manipulator and sample acquisition, pattern
recognition/screen analysis, large scale associative memories, multi-channel
micro processor arrays, development of real time dynamic modeling techniques.

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF _____

TITLE Roving Vehicles, Sample Selection/Acquisition NO. 1.8.10/E1/2
 _____ THEME / W.G. / TASK

 _____ DATE 4 / 26 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Expand existing development programs to include sample selection/
acquisition capability extend software development activity.

7. ALTERNATIVE APPROACHES/OPTIONS Astronauts

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Robotics/Teleoperator Development at JPL

RTOPS 186-68-55, 506-19-32

9. TECHNOLOGY SCHEDULES

FY

[illegible][illegible]

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL OF STATE OF ART

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF _____

1. TITLE Precision Pointing of Spacecraft and Instruments at Inertially-Fixed Targets NO. 1,7,8,9,12/E1/3 THEME / W.G. / TASK
DATE 4 / 28 / 76

2. OBJECTIVE
A comprehensive program to provide systems to precisely point spacecraft or scientific instruments at inertially-fixed targets.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 4, WILL BE LEVEL ☒ 6 UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1990
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☒ SPACE FLIGHT TEST ☒
OTHER (Specify) ☒ Computer simulation (Check one or more)
f) R&T BASE CANDIDATE 506-19-13 150K, 506-19-15 125K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Digital control system design techniques, microprocessors, CCD arrays.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Implementation of modern control theory algorithms, including:
Kalman filters and state estimators for multi-input and multi-output systems
Adaptive and learning control laws
Advanced mount technology
Computer-aided design and simulation techniques
Advanced sensor development, including:
CCD focal plane sensors
CCD acquisition and star trackers
Gyros - laser, tuned-rotor, magnetically supported
Advanced actuator technology
Control of flexible bodies - control/body interaction

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF _____

TITLE Precision Pointing of Spacecraft and Instruments NO. 1,7,8,9,12 / E1 / 3
at Inertially-Fixed Targets THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

A broad based in-house program of analysis, simulation and hardware,
supplemented with contract activity as required. Laboratory demonstration,
aircraft testing and space flight testing should all be employed as new
elements become available.

7. ALTERNATIVE APPROACHES/OPTIONS No alternatives exist because current technologies will not meet all the requirements for fixed target programs.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOF, OTHER)

RTOP 506-19-13 for advanced S/C and control systems

M/PTL/EIPS Study for Space Lab Test Capability 977-10-20 Spacelab IPS Dynamics

RTOP 506-19-15 Video Inertial Pointing

9. TECHNOLOGY SCHEDULES

FY

[illegible][illegible]

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF _____

1. TITLE Precision Pointing and Tracking Systems
for Non-Inertial TargetsNOI, 7, 10, 11 / E1 / 4
THEME / W.G. / TASKDATE 4 / 28 / 76

2. OBJECTIVE

A comprehensive program to provide systems capable of precisely pointing and tracking at high rates ($.1^0/\text{sec.}$) non-inertial targets. This technology is applicable to planetary and earth pointing spacecraft and platforms.

3. NEED ANALYSIS

- a) LEVEL NOW ☐ 4, WILL BE LEVEL ☐ 6 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☐ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1990
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☒ SPACE FLIGHT TEST ☒
OTHER (Specify) ☒ Computer simulation (Check one or more)
- f) R&T BASE CANDIDATE 506-19-13, 14, 15 300K, 150K, 100K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY Improved digital system design techniques,
CCD array technology, microprocessor technology.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Advanced trackers, including:
Advanced CCD technology
Target body tracking algorithms
Landmark tracking algorithms

Precision actuators, including:
Magnetic suspension
Magnetic bearing reaction wheels

Flexible vehicle configuration control - including modeling of flexible vehicle dynamics in control laws

Advanced onboard processors - microcomputers

High precision real-time orbit determination using the global positioning system

Radiation of sensors and electronics.

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
OF STATE
OF ART

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF _____

TITLE Precision Pointing and Tracking Systems for
Non-Inertial Targets

NO. 1,7,10,11/EI-4
THEME / W.G. / TASK

DATE 04 / 28 / 76 -2200

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

A Broad based in-house program for technology supplemented with contracts as required for hardware development. Hardware demonstrations supported by system analysis and simulation leading to aircraft and spaceflight testing as appropriate.

7. ALTERNATIVE APPROACHES/OPTIONS

processing of data obtained

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-19-14 RTOP Provides basic CCD Sensor Technology and momentum wheel technology. 506-19-13 provides magnetic suspension technology. MIPTL Study for Flight Test

9. TECHNOLOGY SCHEDULES

FY

[illegible][illegible]

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF _____

1. TITLE Autonomous Navigation - Earth Orbiters NO. 7.11.9.12/E-1/5
THEME / W.G. / TASK
DATE 4 / 27 / 76

2. OBJECTIVE To reduce mission operations costs by utilizing on-board systems to perform mission planning, orbit station keeping, altitude control

3. NEED ANALYSIS

- a) LEVEL NOW ☐ 4, WILL BE LEVEL ☐ 7 UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☐ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1985
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☐ LOW ☒
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
e) TASKS NEEDED: STUDY ☐ ANALYSIS ☒ RESEARCH ☐
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒
OTHER (Specify) ☐ _____ (Check one or more)
f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY On-board navigation sensors, GPS receivers, advanced low thrust propulsion

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- On-board orbit determination utilizing either on-board navigation sensors or external navigation data services (GPS)
- Combined orbit/altitude/sensor control laws and mission objective models
- Advanced user/and altitude communication systems and on-board command management

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 2 OF

TITLE Autonomous Navigation - Earth OrbitersNO. 7,11,12/E1/5

THEME / W.G. / TASK

DATE 4 /27 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Development of combined altitude/orbit/sensor control laws and act ators.Development of mission models and command management systems utilizing
minimal ground support operations.7. ALTERNATIVE APPROACHES/OPTIONS High cost mission operations

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

310-10-22, 23 RTOP

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
On Board/Ground																				
Systems Develop.	Δ				▼															

MANPOWER (M-Y)
INHOUSE
CONTRACT

2

2

2

2

2

FUNDING (10⁶ \$)
INHOUSE
CONTRACT

.2

.3

.5

.5

.5

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF _____

1. TITLE Dynamics and Control of Unmanned
Entry and LandingNO. 10, 12 E1 6
THEME / W.G. / TASKDATE 4 / 27 / 76

2. OBJECTIVE

To provide technology readiness for planetary atmospheric probes,
and selective lander spacecraft, and advanced STS vehicles.

3. NEED ANALYSIS

a) LEVEL NOW ☐ 4, WILL BE LEVEL ☐ 7 UNDER EXISTING PLANS.b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☐ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1988

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☒ LOW ☐d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☐
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY Heat shield technology, probe structures,
planetary atmospheres, in-situ control sensors.5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEEDVehicle and path control concepts and hardware mechanizationsto utilize aerodynamic control in planetary atmospheres (with large
unknowns if vehicle is for other than earth).Navigation and guidance concepts and mechanizations to autonomouslyland at selected sites with minimum landing dispersions.Navigation and guidance concepts and mechanizations for automatic
earth landing.5. COMPONENT OR BREADBOARD TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 2 OF 2

TITLE Dynamics and Control of Unmanned
Entry and Landing

NO. 10,12 E1 6
 THEME / W.G. / TASK

DATE 4 / 27 / 75

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

For given entry configurations, the development of control algorithms which are insensitive to atmospheric dispersions and/or use in-situ sensing for adaptive path control. The development of external sensing devices (imaging systems) and/or homing devices for terminal navigation and path control.

7. ALTERNATIVE APPROACHES/OPTIONS Continue to accept large landing/
impact dispersions. Develop guided terminal descent system.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

ARC sponsored planetary workshops/planetary probe development. LaRC/JPL
Viking Program. Shuttle automatic landing system

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Lifting Body																				
Control																				
Terminal Nav.																				
Systems																				
Flt. Test Concept & Test																				

MANPOWER (M-Y)
 INHOUSE
 CONTRACT

2 3 5 5 7 7 7
 5 5 7 10 7 3 3

FUNDING (10⁶ \$)
 INHOUSE
 CONTRACT

.05 .05 .1 .1 .05 .05 .05
 .2 .2 .7 .7 .8 .5 .3

5. COMPONENT OR DREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF _____

1. TITLE Automatic Stationkeeping

NO. 7, 8, 10, 9/E1/7

THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

To demonstrate the ability to precisely stationkeep (six states) multiple non-physically coupled space structures relative to each other or earth references

3. NEED ANALYSIS

a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 2 UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1988

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☒ LOW ☐

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☐ ANALYSIS ☒ RESEARCH ☒

GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒

OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Orbital mechanics improvements, large structures stabilization and control.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Objective can be met through the development of sensors for attitude and position determination, stationkeeping strategies (positive control) for vehicles in different orbits, and control effectors compatible (will not interfere) with signals attempting to be detected.

2	3	5	1	2	2
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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF

1. TITLE CONTROL OF SPINNING SPACECRAFT
(ARTIFICIAL GRAVITY)

NO. 8/E1/8
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE TO CREATE AN ARTIFICIAL GRAVITY EFFECT FOR HUMAN
HABITATS AND SPACE PROCESSING

3. NEED ANALYSIS

- a) LEVEL NOW ☐ 9, WILL BE LEVEL ☐ 5 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☐ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1985
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☐ LOW ☒
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☐ ANALYSIS ☒ RESEARCH ☐
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒
OTHER (Specify) ☒ COMPUTER SIMULATION (Check one or more)
- f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY CONTROL OF FLEXIBLE STRUCTURES

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

- CONTROL SYSTEM FOR SPINNING FLEXIBLE VEHICLES.

5. COMMENT ON OBSERVABLE EFFECTS IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. DATA PHENOMENA OBSERVED AND REQUIRED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
STATE
PART

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SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF _____

TITLE Control of Spinning Spacecraft

NO. 8 / E1 / 8
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Perform analytical studies and simulations of proposed control systems.

Design of Flight Experiment(s) (Scale Model)

Flight Test Scale Model

7. ALTERNATIVE APPROACHES/OPTIONS

Zero "G" for man in space.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Analysis	→	→																		
Simulation		→	→	→																
Design			→	→	→															
Integr & C/O				→	→	→														
Flight Test					→	→														

MANPOWER (M-Y)

INHOUSE

CONTRACT

2 2 2 3 4

FUNDING (10⁶ \$)

INHOUSE

CONTRACT

.2 .3 .5 .5 .5

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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF

1. TITLE AUTONOMOUS OPERATIONS AND MISSION NO. 1, 7, 8, 10, 11, 12/E1/11
MODIFICATION THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

EXTEND THE AUTONOMOUS NAVIGATION TECHNOLOGY TO
INCLUDE CAPABILITY TO PROVIDE ADAPTIVE ON-BOARD SEQUENCE
MODIFICATION TO AUTONOMOUSLY REACT TO RECEIVED SCIENCE DATA

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 1, WILL BE LEVEL ☒ 1 UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1990
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☒ MEDIUM ☐ LOW ☐
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
f) R&T BASE CANDIDATE 506-19-21 (50K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY COMPUTING HARDWARE TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

- DECISION MAKING LOGIC, PARTICULARLY MULTI-LEVEL AND
MULTI-STAGE DECISIONS

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
STATE
J.F. ART

21 *Continued*

SPACE TECHNOLOGY NEED

PAGE 2 OF 2

TITLE Autonomous Operations & Mission Modification

NO. 1,7,8,10,11,12/E1 / 11

THEME / W.G. / TASK

DATE 4/27/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Study alternate approaches using candidate experiments, bringing the technology to level 5 prior to defining a specific demonstration flight experiment. Detailed laboratory and simulation modeling of mission situations, under varying levels of onboard simulated control.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-19-21

9. TECHNOLOGY SCHEDULES

FY

[illegible][illegible]

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY

6. MODEL TESTED IN AIRCRAFT ENVIRONMENT

7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

FORM NO. 1
PAGE 1 OF _____

NO. 1,9,10,12/E1/13

DATE 4 / 28 / 76

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 3, WILL BE LEVEL ☒ 3 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1985
- c) RISK IN ACHIEVING ADVANCEMENT: HIGH ☐ MEDIUM ☐ LOW ☒
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☐
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☒ Computer Simulation (Check one or more)
- f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Low Thrust Engine Technology

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

1. Develop low thrust navigation and guidance analysis techniques.
2. Develop prototype operational navigation software.
3. Develop low thrust compatible orbit determination techniques and control strategies.
4. Develop precision means of controlling engine thrust magnitude and direction.

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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 2 OF

TITLE Low Thrust Guidance and Navigation

NO. 1,9,10,12/E1/13

THEME / W.G. / TASK

DATE 4, 28, 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Study and select from among a number of promising candidates, the low thrust navigation system of choice. Develop prototype navigation operation software. Ground test engine thrust magnitude and direction control.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

186-67-74 (75K)

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Nav. System Design																				
Software																				
Ground Test																				

MANPOWER (M-Y)
INHOUSE
CONTRACT

4 6 6 3

FUNDING (10⁶ \$)
INHOUSE
CONTRACT

.3 .5 .5 .4

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5. COMPONENT OR BREAKDOWN TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF

1. TITLE Autonomous Rendezvous and Docking

NO. 7-12 / E1 / 14
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

To develop a cooperative rendezvous and docking capability between a "target" vehicle and the rendezvous vehicle.

3. NEED ANALYSIS

a) LEVEL NOW ☐ , WILL BE LEVEL ☒ UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ FOR OPERATIONAL SYSTEM USE BY DATE: 1985

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☒ LOW ☐

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☐ ANALYSIS ☒ RESEARCH ☐

GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒

OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Improve ground operations reaction time to reduce onboard system complexity on initial applications.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Program must include development of

(1) Rendezvous navigation system analysis capability; i.e., design, analysis, optimization of rendezvous strategies.

(2) Inter vehicle range, range rate, and angle detection and sensing systems.

(3) Onboard information processing/decision/command structure technologies.

(4) Precision proximity and attitude alignment sensing for final closure and latching.

NO. 7.12/E-1/14

DATE 4 / 27 / 76

8. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Conduct a program leading from early trade-off studies on hardware and technique alternatives through to a shuttle based demonstration probably with the shuttle playing a passive role and a prototype vehicle docking with it.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

FY

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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF

1. TITLE ATTITUDE, FIGURE, AND STABILIZATION
CONTROL OF LARGE SPACE STRUCTURES AND
ARRAYS

NO. 7.8.9.11/E1/15
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

To stabilize and control the attitude of a large flexible structure whose geometry, mass distribution, attitude, and orbit may change while in orbit

3. NEED ANALYSIS

a) LEVEL NOW ☐ , WILL BE LEVEL ☐ UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☐ FOR OPERATIONAL SYSTEM USE BY DATE: 1988

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☒ LOW ☐

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒

OTHER (Specify) ☒ Computer Simulation (Check one or more)

f) R&T BASE CANDIDATE RTOP 506-19-14, \$50K, 506-19-13, \$50K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY

a. Estimation Filter Development; b. Attitude Control of large-scale flexible structures; c. Hierarchical control theory; d. Stability theory of nonlinear digital control systems; e. High ISP Propulsion; f. Improved motion sensors (i.e. distributed, CCD, etc.)

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

- Alternate structure and array configuration concepts
- Adaptive and other appropriate control system techniques
- Concepts for efficient use of multiple effectors such as CMG's, magnets, energy and momentum storage devices, etc.
- Figure control system.
- Figure error sensors such as laser devices
- Estimation and observer theory and use of distributed sensors and actuators.

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 2 OF

TITLE ATTITUDE, FIGURE, AND STABILIZATION CONTROL
OF LARGE SPACE STRUCTURES

NO. 7, 8, 9, 11/EI/15

THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- a. Study alternate configuration concepts
- b. Develop large-scale high-fidelity model of system to portray dynamics
- c. Extend control, estimation, and observer theory as required.
- d. Develop hardware (Items 5d, 5e)
- e. Develop in-orbit test methods
- Develop test model

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-10-1A

910-08-01,-02

9. TECHNOLOGY SCHEDULES

FY

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SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 1 OF 2

1. TITLE Integrated Power and Attitude
Control Systems (IPACS)

NO. 7, 11 /EI/16
THEME /W.G. / TASK

DATE Apr /26/ 1976

2. OBJECTIVE

To develop the technology required for design and development
of combined energy storage and momentum storage fly wheel

systems.

3. NEED ANALYSIS

a) LEVEL NOW ☒ 2, WILL BE LEVEL ☐ 3 UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1985

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☐ LOW ☒

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☐ MEDIUM ☒ LOW ☐

e) TASKS NEEDED: STUDY ☐ ANALYSIS ☐ RESEARCH ☐
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒

OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

- Composite Wheel Development and Testing
- Advanced High Frequency, High Power, Solid State Motor
and Generator Electronics
- High Speed Magnetic Bearings

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
OF STATE
OF ART

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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF

1. TITLE CHECKOUT, SELF TEST, AND REPAIR (STAR)

NO. A11 / E-1 / 18
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

To provide STAR capabilities for GNC systems in order to support
ambitious missions with long life term requirements, and to reduce costs,
ground support, turnaround time and to prevent massive abort.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 5 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1990
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☐ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☒ SPACE FLIGHT TEST ☒
OTHER (Specify) ☒ Computer Simulation (Check one or more)
- f) R&T BASE CANDIDATE 506-19-14 \$20K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY

Adaptive software research required for self test and repair of other
subsystems.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

Develop redundant controls configuration
Develop multi-microprocessor arrays
Determine optimum strategy in failure and environmental context.

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
OF STATE
OF ART

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TITLE Checkout Self Test and Repair (STAR)

NO. 10/E-1/18

THEME / W.G. / TASK

DATE 4 / 28/ 76

A coordinated, iterated program of technique, hardware, and software development of fault tolerant and redundant guidance and control system for the Planetary Exploration Facility

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-19-14

FY

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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF

1. TITLE COMPUTER-AIDED CONTROL SYSTEM DESIGN

NO. A11/E1/19

THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

To enhance the efficiency of computers in design of control systems and simulation of vehicle dynamics.

3. NEED ANALYSIS

a) LEVEL NOW 2, WILL BE LEVEL 3 UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL 4 FOR OPERATIONAL SYSTEM USE BY DATE: 1984

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☐ LOW ☒

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒

GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐

OTHER (Specify) ☒ Computer Simulation (Check one or more)

f) R&T BASE CANDIDATE RTOP 506-10-13, \$75K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- Extend and improve existing techniques for designing sampled-data (digital) control systems to select control system gains and computer sample periods.
- Extend capability to analyze digital control system containing significant nonlinearities in attempt to obviate limit cycle phenomena.
- Extend ability to specify quantization of sensed parameters.
- Design computer-aided design techniques for optimizing digital controllers and filters.

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OFTITLE Computer-Aided Control System DesignNO. 1 E1 19

THEME / W.G. / TASK

DATE 4/ 28/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- Extend techniques for selecting digital control system gains and sample periods.
- Extend capability to analyze digital control systems containing significant nonlinearities - predict and obviate limit cycles.
- Extend ability to define quantization levels of sensed parameters.
- Develop optimization techniques for digital controlled and filter design.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

910-08-01, -02506-19-13

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
6a Digital Gain & Sample Period Selection					▲															
6b Nonlinear Anal.					▲															
6c Quantization					▲															
6d Filter design																				
Modular Adaptable Software Pkg (MASP)																				

MANPOWER (M-Y)

INHOUSE

CONTRACT

2 3 4 4 3 2

FUNDING (10⁶ \$)

INHOUSE

CONTRACT

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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF _____

1. TITLE Autonomous Terminal Navigation
for Planetary Body Approach

NO. 1.10 /E-1/20

THEME /W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

Develop and demonstrate ability to autonomously control flight path and
instrument pointing relative to a target.

3. NEED ANALYSIS

a) LEVEL NOW ☐ 2, WILL BE LEVEL ☐ 5 UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☐ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1990

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☒ LOW ☐

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☐ ANALYSIS ☐ RESEARCH ☐

GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒

OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE 506-19-21 (500K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

Develop flight sensor and processing capability for the precision
detection and center finding of the planetary body relative to a star field.
Develop on-board information processing/decision/command structure
technologies.

5. COMPONENT OR BREAKDOWN TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 2 OF

TITLE Autonomous Terminal Navigation for Planetary
Body Approach

NO. 1.10 /E-1/20

THEME / W.G. / TASK

DATE 4 /27 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Extend current R&T program to include a flight/ground demonstration of a system to autonomously deliver a spacecraft and point its instruments to a target planet, satellite, asteroid, or comet. Test on J0 '81 or other suitable mission.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-19-21 (500K)

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Flt. H/W Dev.				—	Δ															
Ground Computer				Δ																
Grnd S/W Devel.				—	Δ	—	Δ													
Lunar Test					Δ															
Jupiter Test								—	Δ											
Technology Read.									Δ											

MANPOWER (M-Y)
INHOUSE
CONTRACT

FUNDING (10⁶ \$)
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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF

1. TITLE EXTENDED LIFE ATTITUDE CONTROL
SYSTEMS (EACS)

NO. 1,7-11/EI/21
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

TO DEVELOP THE TECHNOLOGY AND DEMONSTRATE AN ATTITUDE
CONTROL SYSTEM CAPABLE OF LONG LIFE THROUGH FAULT TOLERANCE
AND APPLICABLE TO A WIDE RANGE OF UNMANNED, EARTH ORBITAL, AND

3. NEED ANALYSIS PLANETARY PROGRAMS.

- a) LEVEL NOW ☒ 3, WILL BE LEVEL ☒ 5 UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY [DATE: 1984]
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☐ LOW ☒
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
e) TASKS NEEDED: STUDY ☐ ANALYSIS ☐ RESEARCH ☐
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
f) R&T BASE CANDIDATE RTOP 506-19-14 FY 78 NOA \$450K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY MICROPROCESSOR TECHNOLOGY, CCD TECHNOLOGY
MAGNETIC BEARING, DIGITAL SYSTEM TECHNOLOGY
506-19-14 (450K)

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

1. TO PROVIDE THE SYSTEM DESIGN FOR INTERFACING SENSORS, COM-
PUTERS, AND ACTUATORS AND PROVIDING THE REDUNDANCY AND
EXPENDABLE MANAGEMENT WITH SIMPLICITY OF CROSS-STRAPPING
AND INCREMENTAL ADD-ON CAPABILITY.
2. DEVELOP THE CONTROL ANALYSIS TOOLS TO DEAL WITH FLEXIBLE
VEHICLE EFFECTS.
3. TO DEVELOP A FAULT TOLERANT PROGRAMMABLE ATTITUDE CONTROLLER
WITH FAULT DETECTION AND CORRECTION CAPABILITY.
4. DEVELOPMENT OF A MAGNETIC BEARING REACTION WHEEL.
5. TO DEVELOP A MICROPROCESSOR CONTROLLED CCD STAR TRACKER.
6. RADIATION HARDENING OF COMPONENTS AND ELECTRONICS.

5. COMPONENT OR SUBSYSTEM TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. EACH PHENOMENON OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENON
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
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5. COMPONENT OR BREAKDOWN TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
OF STATE
OF ART

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF

1. TITLE ROBOTICS AND TELEOPERATORS FOR
SPACECRAFT ASSEMBLY, MAINTENANCE AND
REPAIR

NO. 1,7,8,9,11/E-1/23

THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

DEVELOP A GENERAL CLASS OF ROBOTIC DEVICES WITH SUFFICIENT DEXTERITY TO
PERMIT MECHANICAL OPERATIONS IN SPACE.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 5 UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1987
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☒ MEDIUM ☐ LOW ☐
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐ DEPENDING ON APPLICATION
e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒
OTHER (Specify) ☒ COMPUTER SIMULATION (Check one or more)
f) R&T BASE CANDIDATE Yes 506-19-32 (250K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY ADVANCED SOFTWARE SYSTEMS, HIGH CAPACITY
ENERGY STORAGE, ARTICULATE MANIPULATORS, LOW THRUST PROPULSION.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

(1) SCENE AND IMAGE ANALYSIS PROCESSOR

(2) ROBOTIC EYE/HAND COORDINATION

(3) NAVIGATION IN CONFINED SPACE

(4) RADIATION HARDENING (FOR SOME APPLICATIONS)

ALL INFORMATION CONTAINED
HEREIN IS UNCLASSIFIED

PAGE 2 OF

1,7,8,9,11
NO. /EI/23
THEME /W.G./ TASK

DATE 04 / 27 / 76

Increase current teleoperator and robotics development program to include dexterous manipulator systems, image processing/video link systems, and inertial stabilization as appropriate for free flying teleoperators.

Robotics/Teleoperator development at JPL RTOP 186-68-55 GCC Technology,
506-19-32

FY

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5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED		FORM NO. 1
		PAGE 1 OF _____
1. TITLE	Advanced GN&C Components for the STS Systems	NO. 1,12/E-1/26 THEME / W.G. / TASK DATE 4 / 28 / 76
2. OBJECTIVE	Improve performance, operational costs, reliability, and operating life of future STS systems.	
3. NEED ANALYSIS	a) LEVEL NOW ☒ 5, WILL BE LEVEL ☒ 7 UNDER EXISTING PLANS. b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 7 FOR OPERATIONAL SYSTEM USE BY ☐ DATE: 1985 c) RISK IN ACHIEVING ADVANCEMENT: HIGH ☐ MEDIUM ☒ LOW ☐ d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐ e) TASKS NEEDED: STUDY ☐ ANALYSIS ☒ RESEARCH ☐ GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒ OTHER (Specify) ☒ Hardware Development (Check one or more) f) R&T BASE CANDIDATE 506-19-14 (50K), 505-25-07 (105K)	
4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY	CCD technology, power electronics, general electronic technologies	
5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED	Advanced systems will require the demonstration of electromechanical speed control for flight control systems, the application of new sensor elements to inertial reference units, and star trackers, and new rendezvous sensors to replace conventional radar. Technology advances in onboard data processing system architecture will be required to insure the optimum processing configuration consistent with GN&C requirements. Such architectures may involve hierarchies of microprocessors for subsystem level processing.	

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 2 OF _____

TITLE Advanced GN&C Components for the STS System

NO. 112/E-1/26

THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

The basic technology is now being developed but needs to be integrated at the subsystem level. The basic approach would be to select the technology to be introduced (lasers, CCDs, etc.) and to enter into a separate technology development program for each component at the component/subsystem level.

7. ALTERNATIVE APPROACHES/OPTIONS Continue to use obsolete technologies.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

MSFC Laser Gyro Program; JSC Electromechanical Actuator program. JSC

Advanced Orbiter/System Concept Studies. Ames/JPL VIP tracker develop-
ment: JPL RTOP 506-19-14. CCD Tracker Dev.

9. TECHNOLOGY SCHEDULES

[illegible][illegible]

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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF

1. TITLE Dynamics and Control of Manned Aerospace
Vehicles

NO. 12 E1 27

THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

To improve the flying qualities of manned aerospace vehicles

3. NEED ANALYSIS

a) LEVEL NOW ☒ 4, WILL BE LEVEL ☒ 7 UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1983

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☐ LOW ☒

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☐ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☐ AIR CRAFT TEST ☒ SPACE FLIGHT TEST ☒

OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY Hi Speed aerodynamics; aerothermodynamics;
onboard command processing; in-situ sensing.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

Active control technology and handling quality advancements in lifting
body reentry vehicles.

5. COMPONENT OR BREAKDOWN TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

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SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF _____

TITLE Dynamics and Control of Manned Aerospace Vehicles

NO. 12 E1 27
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Analysis of control configured vehicle concepts to advanced shuttle configuration. Advanced control theory concepts and command processing techniques to improve the control of the vehicle dynamics in manual and automatic modes.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

FY

[illegible][illegible]

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF _____

1. TITLE Differential Very Long Baseline

NO. 1,10 / E1 / 28

Navigation Technology (AVLBI)

THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Create a VLBI measurement and measurement processing system

capable of low cost, highly precise (10^{-8} radian Earth relative)

navigation anywhere within the solar system

3. NEED ANALYSIS

a) LEVEL NOW ☒ 3, WILL BE LEVEL ☒ 3 UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1985

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☐ LOW ☒

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☐ ANALYSIS ☒ RESEARCH ☐

GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒

OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE \$1500K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

OTDA sponsored ground systems development

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Create the Design and Analysis Base capable of analyzing measurement accuracy and acquisition requirements.

Create prototype measurement calibration and processing software.

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 2 OF _____

TITLE Differential Very Long Baseline
Navigation Technology (ΔVLBI)

NO. 1,10 / E-1 / 28

THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

A program, cooperating with OTDA ground system development, of requirements analysis, data base gathering, processing and flight demonstration employing the MJS encounters is required.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Design and Analysis Techniques			▼																	
Measurement			▼																	
Processing S/W																				
Measurement																				
Gathering				▼		▼														
Processing				▼	▼	▼														
MJO Proof Testing								▼												

MANPOWER (M-Y)
 INHOUSE
 CONTRACT

FUNDING (10⁶ \$)
 INHOUSE
 CONTRACT

.15 .2 .15 .2 .1 .2

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT												FORM II
(List in numerical order, 1 - Highest Priority)												FORM III
WORKING GROUP <u>E1 NGC</u>												
DATE <u>4 / 29 / 1980</u>												
THEME NO.	7 SPACE POWER	8 SPACE INDUST.	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV. TRANS SYS.	NASA R&T		SUMMARY PRIORITY ASSESSMENT			
TECHNOLOGY NEED NO.							Current	R&T Base	WG	TT	R&T Base	'78 Total
1. Autonomous Guidance & Control of Launch Vehicles						5			17		K\$	K\$
2. Roving Vehicles & Sample Selection		7		8			X	9	15		930	3,000
3. Precision Pointing of Spacecraft & Instruments at inertial targets	2	4	1				X	2	3		275	3,000
4. Precision Pointing & Tracking Systems for non-inertial targets	3			2	1		X	1	2		550	1,000
5. Autonomous Navigation for Earth Orbiters	12				5	4			8			
6. Dynamics & Control of Unmanned Entry & Landing				7		1			9			
7. Automatic Station-keeping	8	3	3	12					10			
8. Control of Large Spinning Spacecraft		5							21			
9. Deleted												
10. Deleted												
11. Autonomous Operations & Mission Modification	10	8		1	2	6	X	5	4		50	200
12. Deleted												
13. Low Thrust Guidance & Navigation			5	3		8	0	10	13		0	300

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SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

(List in numerical order, 1 - Highest Priority)

WORKING GROUP E1 NGCFORM II
FORM IIIDATE 4 / 29 / 1520

TECHNOLOGY NEED NO.	THEME NO.	7 SPACE POWER	8 SPACE INDUST.	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV. TRANS. SYS.	NASA R&T		SUMMARY PRIORITY ASSESSMENT			
								Current	R&T Base	WG	TT	R&T Base	'78 Total
14.	Autonomous Rendezvous & Docking	9	6	3	6	8	2			5		K\$	K\$
15.	Attitude, Figure, and Stabilization Control of Large Space Structures	1	1	2		3		X		1		100	1,000
16.	Integrated Power & Attitude Control Sys.	4				9				16			
17.	Deleted												
18.	Checkout, Self-Test, & Repair (STAR)	7	9	7	9	7	7	X	8	11		20	200
19.	Computer-aided Control System Design	11	10	6	10	10		X	4	12		75	425
20.	Autonomous Terminal Navigation for Planetary Body Approach				5			X	6	14		500	1,300
21.	Extended Life Attitude Control System	5	11	4	4	6		X	3	7		450	750
22.	Deleted												
23.	Robotics & Teleoperators for Spacecraft Assembly & Maint.	6	2	9		4		X	7	6		200	1,500
24.	Deleted												
25.	Deleted												
26.	Advanced GN&C Components for Advanced Shuttle						9	X	11	18		300	700

[illegible]